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*Capital quasi-fixity and the estimation of markups **

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Résumé

Le traitement des coûts du capital, soit comme coûts fixes ou variables, est essentiel pour l'estimation des mark-ups. Les données penchent nettement pour l'hypothèse de fixité, ce qui explique les hauts niveaux de mark-up relevés dans des études précédentes utilisant la méthodologie de Roeger. L'estimation directe du ratio de la production sur les coûts variables est préférable.

Mots clés: Mark-ups, Fixité du capital, Concurrence imparfaite

Abstract

The treatment of capital costs, as either fixed or variable, is key for estimating markups. Data leans clearly towards fixity, which explains the high markups emphasized in previous studies based on Roeger's methodology. Direct estimation from the ratio of output over variable costs is preferable.

Keywords: Markups, Capital Fixity, Imperfect Competition

JEL Classification: L11, L13, L60

1. Introduction

Industrial economics is indebted to Hall (1986) for estimating markups at sectoral levels. Improvements have then been proposed by Basu (1995) who highlights the quantitative importance of paying greater attention to materials, and by Roeger (1995), who derives a new methodology that circumvents intricate endogeneity issues in Hall's approach. First, it is argued here, that both methodologies should lead to a cautious quantitative interpretation of the respective markup estimates in terms of profit ratios, and second, that the shortcomings in Roeger's estimates reveal specification rather than measurement issues. Roeger's overestimation, identified in previous studies, is elucidated and substantiated to the extent that the returns to scale on the variable factors are decreasing.

2. Roeger's apparent overestimation reveals misspecification issues

The common framework assumes that identical firms in a given sector have the following homogeneous production function:

$$Y = A.\ F\ (K, L, M) \tag{1}$$

where *Y* is output, *K* capital, *L* labor, *M* materials and *A* a productivity term. m denoting the markup over marginal cost and *x* the returns to scale, first order conditions and Euler's equation lead to:

$$P.Y = \frac{m}{x}.\,(R.K + W.L + P_m.M) \tag{2a}$$

where *P* is the price of output, and *R*, *W* and P_m are the respective factor prices of capital, labor and materials. Equation (2a) links the respective factor shares in total output, a_K, a_L, a_M, such that:

$$a_K + a_L + a_M = x / m \tag{2b}$$

dz standing for the logarithm differential of any given *Z* variable, Hall's approach and its extensions proceed from the derivation of equation (1) to:

$$dy = m.(a_K.dk + a_L.dl + a_M.dm) + da \tag{3H}$$

Roeger's specification can be obtained directly by deriving equation (2a):

$$dpy = \tilde{m}\ .(a_K.drk + a_L.dwl + a_M.dp_m m) \tag{3R}$$

$\tilde{m} \equiv m / x$ standing for the markup adjusted for returns to scale, i.e. the markup over average cost. By substituting the capital share by its expression drawn from (2b) in equations (3H) and (3R), one arrives at:

$$dy = m.[a_L.(dl - dk) + a_M.(dm - dk)] + x.dk + da \qquad (4H)$$

$$dpy - drk = \tilde{m}.[a_L.(dwl - drk) + a_M.(dp_m m - drk)] \quad \text{which is denoted} \quad dx = \tilde{m}.dz \qquad (4Ra)$$

with *dx* and *dz* the respective left-hand side (LHS) and right-hand side (RHS) variables of equation (4Ra). Roeger's equation links the markup to the sensitivity of the capital share to the changes of relative factor shares. In fact, Roeger estimates a specification equivalent to (4Ra) but expressed in terms of the (adjusted) Lerner index $\tilde{L}=1-1/\tilde{m}$:

$$(dx - dz) = \tilde{L}.dx \qquad (4Rb)$$

What are the comparative advantages of each approach? On the one hand, Hall's methodology allows for the identification of both markup over marginal cost and returns to scale, whereas Roeger's can only estimate their ratio which is the markup over average cost as seen from (2a). Moreover, Hall's does not need any computation of rental capital cost contrary to Roeger's, which requires its logarithmic variation. This second impediment is considered so serious that Roeger's is often disregarded. However, this paper shows that this criticism is exaggerated and misses the main point. On the other hand, the main difficulty in Hall's, and that Roeger's avoids, comes from the total factor productivity growth term, *da*, which is correlated to RHS variables in (4H). Estimations should therefore turn to instrumental variables, but finding an efficient and valid instrument is a cumbersome task and most of those proposed have fallen under serious criticism. Another advantage of Roeger's is that it only requires variables in value terms whereas Hall's needs sectoral price indices to compute volume outputs. Moreover, contrary to Hall's, Roeger's specification is unaffected whether the technological change is Harrod-neutral or biased against labor. This last point is generally neglected which is unfortunate given the credit granted to this bias to "explain" important stylised facts such as increasing inequality and decreasing labor shares.

The question of the estimate sensitivity to rental capital cost measures will be addressed later on and should not draw attention away from the main issue. I will now show that Roeger's appears to overestimate the markup and that the mismeasurement of capital costs cannot account for the magnitude of the problem. Assume first that capital stock and cost are measured perfectly, then by denoting *COST*, the sum of costs ($COST = R.K + W.L + P_m.M$), based on equation (2a), the markup $\tilde{m}$ can be estimated directly from:

$$PY = \tilde{m}.COST + u \qquad (5)$$

where *u* are the residuals. Throughout this study, equation (5) is called the benchmark equation, and the estimated markup and estimated residual for date *t* are denoted $\tilde{m}_B$ and u_t respectively. Data for this study is from the OECD STAN database and is described in Appendix A.

Table 1 shows, with US manufacturing sectors as an illustrative example, that Roeger's estimates are much greater than the benchmark, for which Durbin-Watson statistics indicate the need to correct for auto-correlation, although once done, the estimates do not change much.[1] Roeger's markups are greater than the benchmark in 11 out of 14 sectors, being perceptibly lower in 1 sector only, and Roeger's average stands at 5.1 points above the benchmark average. Any possibility that the mismeasurement of capital costs is mainly responsible for the differences in these estimates should be discarded for the following three reasons.

First, as can be read from table 2, this issue proves recalcitrant to very different assumptions for computation of capital data, referring to depreciation, interest rates and initial capital stock.[2]

Second, the capital share of total output, based on our favored computation of capital stock and rental cost – the first one in table 2 used to produce table 1 -, varies from 3.6% for "Leather products and footwear" to 9.8% for "Basic metals" on average over the period, so that mismeasurment cannot cope with the magnitude of the problem. The apparent positive correlation between the difference in estimates and the average capital share (last row of table 2) is distinct and only gives a clue to the source of the problem.

[1] Estimates are produced from an AR(2) process for the residuals. Although it corrects for auto-correlation successfully, a more general treatment would have consisted in an error component model, which allows one to distinguish short term from long term dynamics.

[2] I tested more extreme assumptions with a similar outcome overall.

Third and even more convincingly, Roeger's (apparent) overestimation has been highlighted by other studies based on different database and computations of capital costs, and should therefore be taken as well-established. In other words, differences in estimates from one methodology to another are not mainly due to mismeasurements but rather to misspecifications. Among those studies, Hindriks, Nieuwenhuijsen and de Wit (2000) and Hylleberg and Jorgensen (1998) note that inferred capital shares from Roeger's estimates are unrealistically low as a large proportion run into negative territory. Table 3 compares effective capital shares with implied benchmark and Roeger's ones from $a_K = 1/\hat{\tilde{m}} - a_L - a_M$ and indicates the frequency of negative occurrences. Roeger's estimates, because they (seem to) overestimate markups, indeed lead to capital shares very close to zero on average and negative for around 40% of the 334 observations available for the USA. Note that these results are not very sensitive to the choice of the method for computing capital data, even though the two selected for illustration purposes – the first and third from table 2 – generate important variations in capital share measures. Roeger's original *L*-based estimates from (4Rb) amplify the differences compared to m-based computations and the explanation of why this is the case is given in Appendix B.

In understanding the problem, it is convenient to calculate the difference in the two estimates numerically. Derivation of equation (5) leads to the exact m-based Roeger's equation:

$$dx = \tilde{m}.dz - u/PY.(drk - du/u) \equiv \tilde{m}.dz + v \qquad (6)$$

It then appears that the residuals, *v*, might be correlated with the RHS variable, *dz*. The OLS Roeger estimate of $\tilde{m}$ from (4Ra), $\tilde{m}_R$ is therefore given exactly by using (6):

$$\tilde{m}_R = \tilde{m}_B - \frac{\sum u_t.drk_t.dz_t \;/(PY)_t}{\sum dz_t^2} + \frac{\sum du_t.dz_t \;/(PY)_t}{\sum dz_t^2} \equiv \tilde{m}_B + diff_1 + diff_2 \qquad (7)$$

Equation (7) breaks down the numerical difference in the two estimates into two terms. Table 4 reveals, somewhat surprisingly, that most of it comes from the second term, i.e. from the positive correlation between the first-difference of equation (5) estimated residual and the variable *dz,* itself a complex combination of relative factor shares, a priori negatively related to capital share changes. Given the correlation displayed in the last row of table 2, the potential negative correlation between equation (5) residuals and capital costs might therefore explain most of the difference between Roeger's and benchmark markups.

Finally, Hall's estimates are not reported here. Although they are not very sensitive to the various capital stock measures, the OLS estimates suffer two major shortcomings. Firstly, the precision is much poorer than Roeger's. Secondly, Hall's estimates prove extremely sensitive to the price index which is necessary to derive the volume of materials, as the data provides materials in value terms only. Therefore, I have not even tried to overcome the endogeneity issue. Having given several clues in this descriptive analysis, I now come to what most likely explains the differences in estimates.

3. Capital fixity as the main suspect

Many reasons may invalidate (5). The competition environment in OECD countries has changed substantially over the last thirty years. Assuming markups are constant, as equation (2) implies, might be misleading. Indeed, allowing the markup to be time-dependant enriches equation (2), as is extensively developed in a related paper, Boulhol (2004), but does little to explain the difference between the benchmark and Roeger-type estimates. To see this, consider the specification:

$$PY_t = \tilde{m}_t . COST_t \quad \text{with} \quad \tilde{m}_t = \tilde{m}(X_t) \tag{8}$$

where X_t designates exogenous variables representing the competition environment which determines markup levels at time *t*. m - based Roeger's equation equivalent to (8) becomes:

$$dx = \tilde{m}_t .dz + d\tilde{m} / \tilde{m} \tag{8R}$$

Estimates in (8) and (8R) are compared for a time-dependant markup represented by a polynomial of order up to three. Although the polynomial adds significant explanatory power, i.e. even when accounting for the fact that the steady-state markup $\tilde{m}$ is not so steady, the apparent overestimation persists. Similarly, the impact of economic cycles and price rigidities prove to matter greatly in estimating markups, as shown in Boulhol (2004), but does not help in solving the puzzle.

What does then? Equation (5) holds for *COST* representing the total cost of the true variable factors used by firms to maximise profits. It is essential at this point to insist that the notion of markup we are interested in is not the tautological definition given by the ratio of output to total costs. Rather, it comes from first order conditions in profit maximisation and captures the idea of market power, i.e. the capacity firms have under imperfect competition to mark up variable costs in setting their prices at the desired level: it reflects the intensity of competition, the market structure, the elasticity of demand, etc. If capital is fixed, at least in the short run, then costs related to capital will be fixed costs. They will impact overall profitability but will disappear from the markup equation which becomes:

$$P.Y = \tilde{m}_{fix}.(W.L + P_m.M) \qquad (9)$$

Naturally in this case, the markup is adjusted with returns to scale on the variable factors only.[3]

There is an easy way to check whether equation (9) makes more sense than equation (5). From the following specification:

$$P.Y = \tilde{m}.(W.L + P_m.M) + h.\tilde{m}.R.K + u \qquad (10)$$

If the parameter *h* is not significantly different from *1* then the assumption that capital costs should be considered variable costs and therefore equation (5) cannot be rejected; reciprocally, if *h* is not significantly different from *0* then the assumption that capital is a quasi-fixed factor cannot be rejected. At the 95% (90% respectively) confidence level, taking the most preferred capital computation method, the parameter *h*, is significantly positive in only 23% (28% resp.) of the 132 sectors tested: stated differently, the fixity of capital cannot be rejected in 77% (72% resp.) of the cases. Moreover, this result is robust to various measures of capital stock and cost. Also, the assumption that capital costs should be treated as variable costs (*H0: h = 1*) is rejected in 68% (74% resp.) of the sectors at the 95% (90% resp.) level.

What happens then to Roeger's estimates under the assumption of capital fixity? When equation (9) is derived according to Roeger's methodology, the variable *drk* plays no role, due to fixity, and is removed from variables *dx* and *dz*. As explained below, the systematic bias between the estimates coming from the regression of the then-*dx* variable on the then-*dz* variable and $\tilde{m}_{fix}$ from equation (9) disappears.

However, there is more: when capital is fixed, Roeger's specification given by (4Ra) - which includes *drk* ! – is correct after all.[4] This comes from the fact that the variable *drk* appears in Roeger's equation

[3] Equation (9) is therefore strictly correct only if the production function is homogenous in the labor and material inputs.

[4] Again, keep on mind that the estimated markup is the markup adjusted for returns to scale on variable factors. Hall's equation given by (4H) is also correct under the assumption of capital fixity. Appendix C gives the proofs.

multiplied by the capital share of variable costs, $1-\tilde{m}.(a_L + a_M)$, which equals zero under the assumption of capital fixity leading to equation (9). This means that, if capital is truly fixed - as seems to be acceptable in about three quarters of the time series under study - even though Roeger's equation is derived from a specification treating capital as a variable factor, it generates the correct (adjusted for returns to scale on variable factors) markup over *marginal* cost, equalling the markup over average cost of the variable factors. This latter is obviously greater than the estimated markup over average total cost, obtained when including capital in the benchmark specification. Although it does not give a direct indication of profitability because fixed costs should be subtracted, it remains relevant for assessing changes in market power through time. Consequently, it is no surprise that Roeger's implied capital shares come out close to zero on average.

Table 5 illustrates these results in the case of the USA. The first two columns repeat estimates from table 1. Column 3 gives the benchmark in the case of capital fixity: as is apparent from the last row, the systematic spread with Roeger's disappears. Then, the estimates of equation (10) are successively reported, first bounding *h* between *0* and *1*, and lastly relaxing the constraints. On average, the *h* parameter takes a value of *0.34* and *0.22* respectively and is almost never significantly different from *0*, suggesting a very low speed of capital adjustment to the optimal level. Moreover, the average difference between the unbounded benchmark and Roeger's mostly vanishes, and the average absolute difference (not reported here) is more than halved. Supportively, it is remarkable that when the initial spread between Roeger's and benchmark estimates (first two columns) is high, the corrected benchmark using unbounded estimates, or the very similar capital fixity version (column 3), brings markups closer towards Roeger's.

Finally, Roeger's methodology seems appealing because it is somewhat robust to how capital is treated. However, Roeger's estimates are much less precise than those of the benchmark, as can be seen from table 1, and if capital were truly a variable factor, it is unclear, as discussed extensively by Hindriks et al. (2000), whether Roeger's specification ought to be preferred to that of the benchmark: it is justified only if the relative change of capital costs over time is considered to be more precisely evaluated than the level, which is dubious.

4. Conclusion

This study points out that the treatment of capital costs, as either fixed or variable costs, is central in estimating markups. Measurement issues are secondary. Moreover, the data leans clearly towards the assumption of quasi-fixity of capital. Therefore, the usual estimates must be interpreted with caution, as indeed, a markup over unity is required to cover capital costs, even under a long-term zero profit condition. Finally, Roeger's methodology may overestimate markup levels to the extent that the returns to scale on the *variable* factors are decreasing. To understand this better, consider the Cobb-Douglas case under constant (overall) returns to scale, $Y = K^{a} L^{b} M^{1-a-b}$. Roeger's estimates will then result in $m_R = m/(1-a)$, and even under perfect competition, Roeger's markups will be greater than unity and increasing with long-term capital shares.

Appendix A: Data description

Two samples have been built covering thirteen OECD countries' manufacturing industries at the two-digit level for the period 1970-2000, using International Standard Industrial Classification (ISIC), third revision. One has more detailed information but is sparse, as some sectors are missing for a number of countries, and is composed of 138 time series (a country-sector crossing). The other contains more aggregated data but is more balanced with 132 annual time series available out of a total of 143. Sector identification is given in Table A1. Note that the averages across sectors presented in the following tables are unweighted, i.e. treating each equally, because our prime interest lies in the mechanisms at work rather than in the impact for the total economy.

Sectoral data come from the OECD Structural Analysis (STAN) Database. Table A1 details the 23 manufacturing sectors.

<u>Variables</u>

PROD: Production (Gross Output) at current prices ($P.Y$ in the text)

LABR: Labor compensation of employees ($W.L$ in the text)

VALU: Value added at current prices.

VALUB: Value added at basic prices. When VALUB is available, $P.Y = PROD - VALU + VALUB$.

Materials: $P_m.M = PROD - VALU$.

<u>Capital</u>

The price of capital, p_k , used in the study is the price of investment calculated from the Gross Fixed Capital Formation at current prices (GFCF) and in volume (GFCFK). When data is not available, the price of the GDP deflator (source OECD Economic Outlook) is chosen for p_k . The user cost of capital is calculated classically according to: $R = p_k.(r + d - \dot{p}_k{}^a)$, where *r* is the interest rate, *d* the depreciation rate and $\dot{p}_k{}^a$ is the expected relative change in the price of capital. By default, *r* was chosen as the long-term interest rate (but an alternative with short-term rate was also tested), the depreciation was fixed at *0.05* (but *0.07* was also tested, see below) and $\dot{p}_k{}^a$ was set at the average of the price change over the last three years.

Net capital stock (NCAPK) is available directly in the data for Belgium and Italy only. For the other countries, I calculated the series based on the Gross Fixed Capital Formation in volume (GFCFK) according to: $K_t = (1-d).K_{t-1} + GFCFK_t$. Only, the starting point value for the net capital stock is missing to build the series. It was derived differently depending on the countries, due to data availability. For Austria, Finland, Japan, Norway and the USA, I used the Consumption of Fixed Capital (CFC) and inferred: $p_{k0}.K_0 = CFC_0 / d$ for the first date. For Canada, France, the UK, the Netherlands and Sweden, I computed $p_{k0}.K_0 = c.VALU_0.q$. c is the average, for each sector over time and over countries for which the gross capital stock (CAPK) is available, of $p_k.CAPK / VALU$ and is reported in table A2. The parameter q reflects the ratio of net capital stock to gross capital stock. I ran simulations based on various methodologies (double-decline, geometric, hyperbolic, see OECD, 2001) and reasonable values of parameters to arrive at a ratio of between *0.50* and *0.85*. I chose $q = 0.70$ by default, but compared the results with $q = 0.55$. Finally, as Denmark provides gross capital stock only, I used the constant ratio q to deduce net capital stock for all dates.

I shall now detail the various computations used for the case of the USA as they appear in table 2. *K1* was calculated, as described above, from the investment flows, a depreciation rate *d* of *0.05* and an initial capital stock derived from $p_{k0}.K_0 = CFC_0 / d$. *K2* was calculated similarly but using *d = 0.07*. With the idea of testing extreme assumptions, *K3* was bluntly derived from $p_{kt}.K_t = CFC_t / d$ for every date *t* and *d = 0.05*. *K4* was calculated as *K3* but with *d = 0.07*. I also tested as *r*, the average of the short-term and the long-term rates, and even a constant for the real interest rate.

Appendix B: Comparison of Roeger's L-based and m - based estimates

We want to compare Roeger's m - based markup estimated from (4Ra), $dx = m.\,dz$, which we denote $\hat{m}$ and the original Roeger's estimated from (4Rb), $(dx - dz) = L.dx$, which is written $\hat{m}_L$ based on the estimates of the Lerner index $\hat{L}$. We have the following relations based on OLS estimates without a constant term (in practice adding a constant has no impact and this is not significant):

$$\hat{L} = \frac{\sum dx_t.(dx_t - dz_t)}{\sum dx_t^{\,2}} = 1 - \frac{\sum dz_t^{\,2}}{\sum dx_t.dz_t}.\frac{\left(\sum dx_t.dz_t\right)^2}{\sum dx_t^{\,2}.\sum dz_t^{\,2}} = 1 - \frac{R_m^{\,2}}{\hat{m}}$$

where $R_m{}^2$ is the R-square from (4Ra). It is easy then to conclude that original Roeger's estimates are higher than m - based markups, which aggravates the frequencies of negative implied capital shares, all the more so that the fit in equation (4Ra) is not perfect:

$$\hat{m}_L = \frac{1}{1-\hat{L}} = \frac{\hat{m}}{R_m{}^2} \Rightarrow \hat{m}_L > \hat{m}$$

(the convexity of the relation linking $\hat{m}_L$ to $\hat{L}$ has a very minor impact).

Appendix C: The case of capital fixity

a) Roeger's approach

Roeger's equation cannot be extended to the case of capital fixity because the first order condition on capital is not appropriate in this situation. However, if the production function is homogenous in the variable inputs, then calling x_{LM} the returns to scale on labor and materials:

$$F_L L + F_M M = x_{LM} F$$

First order conditions imply $PY = m / x_{LM} (WL + P_m M)$, which derivation yields:

$$dpy = m / x_{LM} \ .[a_L .dwl + a_M .dp_m m]$$

This is equivalent to equation (4Ra) since the coefficient on *drk* in (4Ra) is $[1 - m / x_{LM} \ .(a_L + a_M)]$ which equals zero under this specification.

In the general case where $q \equiv (F_L L + F_M M) / F = x - F_K K / F$ is not constant, after some calculations, whether capital adjusts perfectly or not, one reaches:

$$dpy = m / q \ .[a_L .dwl + a_M .dp_m m] - dq / q$$

This means that Roeger's and benchmark estimates for the case of capital fixity will differ insofar as $q = x - F_K K / F$ varies with time and that these time changes are correlated with the RHS variable.

b) Hall's approach

It happens that Hall's approach does not need the equalization of marginal revenue of capital with user cost. Therefore, Hall's equation (4H) will be unaffected whether capital adjusts perfectly or not. Indeed, derivation of the production function (1) yields:

$$dy = (F_K K / F).dk + (F_L L / F).dl + (F_M M / F).dm + da$$

The marginal productivity of capital is derived from Euler's equation:

$$\begin{aligned} dy &= (x - F_L L / F - F_M M / F).dk + (F_L L / F).dl + (F_M M / F).dm + da \\ &= (F_L L / F).(dl - dk) + (F_M M / F).(dm - dk) + x.dk + da \end{aligned}$$

First order conditions on labor and materials lead to Hall's equation (4H).

$$dy = m.[a_L.(dl - dk) + a_M.(dm - dk)] + x.dk + da$$

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Table 1: Roeger's apparent overestimation of markups*

			benchmark(OLS)		benchmark (AR2)		Roeger's (OLS)			
Country		ISIC Rev.3	mu	DW	mu	std	mu	std	DW	**difference**
usa	15	Food and Beverages	1.057	0.408	1.024	0.018	1.076	0.019	2.399	**0,052**
usa	16	Tobacco	1.130	0.970	1.124	0.018	1.227	0.057	1.667	**0,103**
usa	19	Leather and Footwear	1.125	0.448	1.039	0.038	1.023	0.057	2.534	**-0,016**
usa	20	Wood and Cork	1.098	0.720	1.096	0.009	1.219	0.028	1.885	**0,122**
usa	21	Pulp and Paper	1.031	0.900	1.032	0.007	1.154	0.025	1.835	**0,122**
usa	22	Printing and Publishing	1.075	1.045	1.075	0.006	1.140	0.035	2.799	**0,065**
usa	23	Coke, Ref.Petrol., Nuclear Fuel	1.041	0.615	1.037	0.016	1.026	0.038	2.194	**-0,010**
usa	24	Chemicals	1.126	0.133	1.143	0.031	1.169	0.029	1.438	**0,026**
usa	25	Rubber and Plastic	1.018	0.606	1.019	0.007	1.065	0.018	2.464	**0,046**
usa	26	Other Non-Metallic Mineral	1.022	0.296	1.038	0.030	1.155	0.032	2.167	**0,117**
usa	27	Basic Metals	0.971	0.467	1.047	0.031	1.125	0.030	2.863	**0,078**
usa	28	Fabricated Metal	1.080	0.162	1.078	0.013	1.105	0.017	1.263	**0,027**
usa	34	Motor Vehicles and Trailers	1.040	0.283	1.062	0.025	1.091	0.034	1.824	**0,029**
usa	35	Other Transport Equipment	0.973	1.027	0.974	0.008	0.925	0.059	2.326	**-0,048**
mean			**1.056**		**1.056**	**0.018**	**1.107**	**0.034**		**0.051**

(*) Capital variables are from the K1 series described in Appendix A.

Table 2: Roeger's apparent overestimation across different measures of capital services and cost*

		benchmark markup estimates				Difference (Roeger's – benchmark)				Average capital share of output			
	sector	K1	K2	K3	K4	K1	K2	K3	K4	K1	K2	K3	K4
usa	15	1.024	1.025	1.028	1.039	**0.052**	0.046	0.076	0.067	0.041	0.037	0.065	0.056
usa	16	1.124	1.285	1.090	1.103	**0.103**	-0.056	0.162	0.150	0.038	0.035	0.066	0.056
usa	19	1.039	1.038	1.053	1.072	**-0.016**	-0.034	0.086	0.069	0.036	0.031	0.093	0.078
usa	20	1.096	1.106	1.029	1.048	**0.122**	0.127	0.165	0.150	0.059	0.053	0.108	0.094
usa	21	1.032	1.038	1.015	1.031	**0.122**	0.127	0.105	0.089	0.086	0.081	0.095	0.082
usa	22	1.075	1.079	1.078	1.090	**0.065**	0.050	0.027	0.013	0.053	0.049	0.062	0.052
usa	23	1.037	1.039	1.030	1.038	**-0.010**	-0.017	0.045	0.037	0.049	0.045	0.056	0.048
usa	24	1.143	1.147	1.046	1.076	**0.026**	0.022	0.123	0.092	0.085	0.078	0.140	0.119
usa	25	1.019	1.022	1.015	1.025	**0.046**	0.038	0.020	-0.001	0.059	0.056	0.056	0.048
usa	26	1.038	1.050	1.027	1.044	**0.117**	0.115	0.117	0.102	0.085	0.077	0.084	0.072
usa	27	1.047	1.055	1.000	1.009	**0.078**	0.080	0.045	0.034	0.098	0.082	0.073	0.063
usa	28	1.078	1.083	1.040	1.056	**0.027**	0.019	0.064	0.046	0.052	0.047	0.082	0.069
usa	34	1.062	1.065	1.019	1.042	**0.029**	0.033	0.055	0.035	0.056	0.050	0.158	0.136
usa	35	0.974	0.979	1.003	1.008	**-0.048**	-0.083	0.018	0.013	0.057	0.050	0.030	0.025
mean		**1.056**	**1.072**	**1.034**	**1.049**	**0.051**	**0.034**	**0.079**	**0.064**	**0.061**	**0.055**	**0.083**	**0.071**
difference / capital share correlation						*0.40*	*0.62*	*0.42*	*0.34*				

(*) Capital variables are described in Appendix A. Sector description is given in Table 1.

Table 3: Implied average capital shares from $a_K = 1/\hat{\tilde{m}} - a_L - a_M$

			Capital computation : K1					Capital computation : K3				
		Frequency of Labor +Materials shares greater than 1	Frequency of negative implied capital share		Average capital share			Frequency of negative implied capital share		Average capital share		
Coun-try	Sec-tor	data	bench-mark	Roe-ger's	data	bench-mark	Roe-ger's	bench-mark	Roe-ger's	data	bench-mark	Roe-ger's
usa	15	0.00	0.00	0.21	0.041	0.066	0.018	0.00	0.52	0.065	0.062	-0.004
usa	16	0.00	0.04	0.71	0.038	0.069	-0.006	0.00	0.78	0.066	0.097	-0.024
usa	19	0.00	0.00	0.00	0.036	0.112	0.126	0.00	0.39	0.093	0.099	0.030
usa	20	0.00	0.00	0.87	0.059	0.063	-0.029	0.00	0.73	0.108	0.122	-0.012
usa	21	0.00	0.00	0.83	0.086	0.083	-0.020	0.00	0.39	0.095	0.099	0.007
usa	22	0.00	0.00	0.25	0.053	0.060	0.007	0.00	0.00	0.062	0.058	0.034
usa	23	0.00	0.08	0.00	0.049	0.057	0.067	0.00	0.35	0.056	0.064	0.026
usa	24	0.00	0.04	0.42	0.085	0.050	0.030	0.00	0.39	0.140	0.130	0.031
usa	25	0.00	0.00	0.13	0.059	0.054	0.012	0.00	0.00	0.056	0.058	0.039
usa	26	0.00	0.03	0.87	0.085	0.066	-0.032	0.03	0.77	0.084	0.076	-0.024
usa	27	0.00	0.17	1.00	0.098	0.019	-0.047	0.00	0.13	0.073	0.063	0.020
usa	28	0.00	0.00	0.29	0.052	0.045	0.023	0.00	0.26	0.082	0.079	0.024
usa	34	0.00	0.21	0.42	0.056	0.020	-0.004	0.04	0.35	0.158	0.061	0.009
usa	35	0.21	0.13	0.04	0.057	0.047	0.101	0.21	0.26	0.030	0.017	0.000
mean		**0.015**	**0.050**	**0.430**	**0.061**	**0.058**	**0.018**	**0.020**	**0.380**	**0.083**	**0.077**	**0.011**

Table 4: Breakdown of Roeger's / benchmark difference according to equation (7)

		Capital series : K1			Capital series : K3		
country	sector	difference	diff1	diff2	difference	diff1	diff2
usa	15	0.052	0.010	0.042	0.076	-0.012	0.088
usa	16	0.103	0.050	0.054	0.162	0.043	0.119
usa	19	-0.016	0.031	-0.047	0.086	-0.010	0.096
usa	20	0.122	-0.011	0.134	0.165	0.009	0.156
usa	21	0.122	-0.020	0.142	0.105	-0.011	0.116
usa	22	0.065	0.024	0.041	0.027	-0.016	0.044
usa	23	-0.010	-0.015	0.005	0.045	0.002	0.043
usa	24	0.026	-0.103	0.129	0.123	-0.042	0.165
usa	25	0.046	-0.012	0.058	0.020	0.000	0.019
usa	26	0.117	-0.017	0.134	0.117	0.004	0.113
usa	27	0.078	-0.064	0.142	0.045	-0.030	0.075
usa	28	0.027	-0.030	0.057	0.064	-0.019	0.083
usa	34	0.029	-0.053	0.082	0.055	-0.091	0.146
usa	35	-0.048	-0.034	-0.014	0.018	-0.023	0.041
mean		**0.051**	**-0.018**	**0.068**	**0.079**	**-0.014**	**0.093**

Table 5: Capital fixity as the main suspect

$$P.Y = \tilde{m}.(W.L + P_m.M) + h.\tilde{m}.R.K + u$$

country	sector	bench mark AR(2) *h = 1* *(1)*	Roeger's *(2)*	benchmark AR(2) *h = 0* *(3)*		benchmark AR(2) *0< h < 1* *(4)*			benchmark AR(2) unbounded *h* (5)		
		$\tilde{m}$	$\tilde{m}$	$\tilde{m}$	*Stand. Dev.*	$\tilde{m}$	*h*	*Stand. Dev. (h)*	$\tilde{m}$	*h*	*Stand. Dev. (h)*
usa	15	1.024	1.076	1.049	*0.017*	1.043	*0.25*	*0.37*	1.043	*0.25*	*0.37*
usa	16	1.124	1.227	1.171	*0.034*	1.145	*0.57*	*1.10*	1.145	*0.57*	*1.10*
usa	19	1.039	1.023	1.050	*0.039*	1.039	*1.00*	*0.00*	1.037	*1.26*	*1.56*
usa	20	1.096	1.219	1.170	*0.011*	1.170	*0.00*	*0.00*	1.187	*-0.22*	*0.39*
usa	21	1.032	1.154	1.141	*0.008*	1.140	*0.00*	*0.00*	1.180	*-0.33*	*0.22*
usa	22	1.075	1.140	1.146	*0.004*	1.141	*0.07*	*0.51*	1.141	*0.07*	*0.51*
usa	23	1.037	1.026	1.027	*0.024*	1.027	*0.00*	*0.00*	1.042	*-0.93*	*0.84*
usa	24	1.143	1.169	1.158	*0.038*	1.149	*0.18*	*0.35*	1.149	*0.18*	*0.35*
usa	25	1.019	1.065	1.038	*0.025*	1.029	*0.20*	*0.32*	1.029	*0.20*	*0.32*
usa	26	1.038	1.155	1.084	*0.057*	1.084	*0.00*	*0.00*	1.098	*-0.21*	*0.37*
usa	27	1.047	1.125	1.073	*0.006*	1.073	*0.00*	*0.00*	1.123	*-0.44*	*0.09*
usa	28	1.078	1.105	1.100	*0.022*	1.080	*0.96*	*0.33*	1.080	*0.96*	*0.33*
usa	34	1.062	1.091	1.110	*0.019*	1.081	*0.56*	*0.60*	1.081	*0.56*	*0.60*
usa	35	0.974	0.925	1.032	*0.010*	0.974	*1.00*	*0.00*	0.932	*1.79*	*1.05*
mean		**1.056**	**1.107**	**1.096**	*0.022*	**1.084**	***0.34***		**1.091**	***0.22***	

Table A1: ISIC Rev. 3 Classification

	Sector desrciption		More aggregated sample
15	FOOD PRODUCTS AND BEVERAGES	15-16	FOOD PRODUCTS, BEVERAGES AND TOBACCO
16	TOBACCO PRODUCTS	17-19	TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR
17	TEXTILES	20	WOOD AND PRODUCTS OF WOOD AND CORK
18	WEARING APPAREL, DRESSING, DYING OF FUR	21-22	PULP, PAPER, PAPER PRODUCTS, PRINTING AND PUBLISHING
19	LEATHER, LEATHER PRODUCTS AND FOOTWEAR	23-25	CHEMICAL, RUBBER, PLASTICS AND FUEL PRODUCTS
20	WOOD AND PRODUCTS OF WOOD AND CORK	26	OTHER NON-METALLIC MINERAL PRODUCTS
21	PULP, PAPER AND PAPER PRODUCTS	27-28	BASIC METALS AND FABRICATED METAL PRODUCTS
22	PRINTING AND PUBLISHING	29	MACHINERY AND EQUIPMENT, N.E.C.
23	COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	30-33	ELECTRICAL AND OPTICAL EQUIPMENT
24	CHEMICALS AND CHEMICAL PRODUCTS	34-35	TRANSPORT EQUIPMENT
25	RUBBER AND PLASTICS PRODUCTS	36-37	MANUFACTURING NEC; RECYCLING
26	OTHER NON-METALLIC MINERAL PRODUCTS		
27	BASIC METALS		
28	FABRICATED METAL PRODUCTS, except machinery and equipment		
29	MACHINERY AND EQUIPMENT, N.E.C.		
30	OFFICE, ACCOUNTING AND COMPUTING MACHINERY		
31	ELECTRICAL MACHINERY AND APPARATUS, NEC		
32	RADIO, TELEVISION AND COMMUNICATION EQUIPMENT		
33	MEDICAL, PRECISION AND OPTICAL INSTRUMENTS		
34	MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS		
35	OTHER TRANSPORT EQUIPMENT		
36	MANUFACTURING NEC		
37	RECYCLING		

Table A2: Computation of initial capital stock for each sector:

Average over time and countries (Belgium, Canada, Finland, France and Italy) of

$p_k.CAPK\,/\,VALU$

sector	c
15-16	2.75
17-19	2.07
20	3.91
21-22	2.89
23-25	3.31
26	3.15
27-28	3.14
29	1.52
30-33	1.52
34-35	2.39
36-37	2.55